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A STUDY OF MATHEMATICAL ABILITY INVOLVING DIGIT RELATIONSHIPS. FINAL REPORT.

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ATTITUDES OF STUDENTS TOWARD ARABIC NUMBERALS AND THEIR ASSOCIATIONS WITH THE NUMBERS FROM 1 TO 9 WERE INVESTIGATED IN A SERIES OF FIVE STUDIES ON (1) NONQUANTITATIVE ASSOCIATIONS TO NUMERALS AS A FUNCTION OF AGE, ABILITY LEVEL, AND SEX AMONG AMERICAN CHILDREN, (2) COLOR ASSOCIATIONS WITH NUMERALS AMONG MALE COLLEGE STUDENTS, (3) PERSONALITY ATTRIBUTES AND PERFORMANCE ON NUMERICAL ATTITUDE AND PERFORMANCE SCALES, (4) ASSOCIATIONS TO NUMERALS IN ITALIAN, DANISH, AND AMERICAN SAMPLES, (5) SEX DIFFERENCES IN QUESTIONNAIRE RESPONSES TO ITEMS DEALING WITH NUMERALS AND QUANTIFICATION AMONG HIGH SCHOOL STUDENTS. AN ANALYSIS OF THE RESULTS AND CONCLUSIONS WERE PRESENTED FOR EACH OF THE STUDIES. ALTHOUGH THE RESULTS OF THE FIRST STUDY FAILED TO DEMONSTRATE A MEANINGFUL RELATIONSHIP BETWEEN ASSOCIATIONS WITH NUMERALS AND ARITHMETIC ATTAINMENTS, THE AUTHOR CONCLUDED THAT THE RESULTS OF THIS INVESTIGATION PROVED A WIDESPREAD CONSENSUS IN THE INTERPRETATION OF NUMERALS AND THE FACT THAT VARIATIONS WITHIN THIS CONSENSUS MAY BE RELATED TO SIGNIFICANT PERSONALITY DIMENSIONS. THE AUTHOR SUGGESTS THAT THE STUDY RESULTS OFFER THE POSSIBILITY FOR DEVELOPING A PERSONALITY TEST OF SOME VALUE. (AL)

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Wesleyan University

Middletown, Conn.

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ACKNOWLEDGMENTS

I should like to make acknowledgments to certain of my colleagues associated in the execution of the research reported in this document and in the preparation of this report. First, I should like to express my obligation to Mr. Dante Aiudi, principal of Central School, Middletown, and his staff for permitting my access to our sample of fourth and seventh grade students, and to Mr. Chauncey Copeland, principal of Woodrow Wilson High School, Middletown, for permitting examination of the tenth grade subjects. Mrs. Mona Clew and Mrs. Jean Smith, respectively, were responsible for the administration of the tests in these schools and their services are gratefully acknowledged.

I am indebted to Mrs. Helen Ehlinger for the compilation of the data on color associations and for the administration of the personality tests and numeral associations reported in the third section of this report. She has also been my principle assistant in the preparation of this report.

In the case of our cross-cultural study, I am particularly indebted to Mrs. Leah Bicchi of Fiesole, Florence, Italy, for obtaining the Italian sample, and Dr. Kurt Palsvig of Stutgarden, Denmark, for obtaining our Danish sample.

The questionnaire on attitudes towards numerals and measurement reported in Study V was devised in cooperation with Mrs. Ehlinger and administered to a high school population by Mrs. Jean Smith of Woodrow Wilson High School in this city.

INTRODUCTION

Man, says Susan Lange, is above all a virtuoso in the manipulation of symbols and this is, in fact, she asserts, the main reason why he has so uniquely transcended all other higher forms of life. His first and most notable demonstration of this capacity was the development of spoken language, an attainment shared by no other creature. A second massive stride in symbolism lay in his devising visual methods of recording speech and abstract concepts. This constituted the development of writing in its multiple forms. In our society we have developed two sets of visual symbols, one designating quantities and the other the alphabet comprising 27 letters. With these primary symbols we record and transmit the major content of our knowledge. These letters and numerals are analogous to the subatomic particles from which the atom, and thereafter the molecules, are constructed in ever higher architechonic form. It is one of the first requirements of the literate member in our society that he master these two sets of symbols.

Circumstances under which these symbols are acquired and the ease with which these become part of one's automatic intellectual machinery must be of prime importance to all subsequent literate intellectual pursuits and attainments. It is, therefore, appropriate that some inquiry be made into the attitudes which individuals bear toward this world of primary visual symbols.

In the present instance we are conducting a research into attitudes toward the quantitative symbols known as numerals. These are ten in number, borrowed from the Arabs, and introduced into our civilization less than a thousand years ago. They replaced the vastly more cumbersome systems used by the Romans, and before that by the Greeks, in which letters of the alphabet were employed in a complicated fashion. Moreover, they included zero, probably one of the greatest single inventions in the history of mathematical notation. As we shall see presently, our inquiries have not extended to the concept of zero because of its unique character of being a "non-number," that is, a symbol which identifies no positive quantity.

Accordingly, our present study is directed toward the manner in which the digits "1" through "9" are appraised not in terms of the quantity they signify, but in terms of what in other times might be called their "illogical" or "emotional" meanings. Numbers in almost all ages have been ascribed these trans-quantitative properties, and it would be futile here to attempt any adequate survey of the instances of which they are bearers of religious meanings, superstitious indications of good or ill fortune, or as symbols from which the future might be divined. Pythagorean philosophy, Christian theology, the traditions of Buddhism are all replete with usages of numerals. There is, in fact, a pseudo science of numerology which

survives to our time and strangely incorporates much of this ancient lore. But apart from formalized tradition ascribing to numerals magical and personalistic attributes there are at least two other grounds for suspecting that these numerals are the bearers of meanings beyond their quantitative significance.

The first of these lies in the character of their configuration, their "physiognomic" properties. Thus, rounded numerals like "3" and "8" contain certain perceptual aspects to distinguish them from linear numerals such as "4" and "7" which are composed of straight lines.[1] Again, and perhaps still more important, is the fact that these symbols are absorbed into the minds of children at a very early age, at which time, as Piaget and many others have shown, when there is a relative inability to grasp abstractions and a strong tendency to endow all components of experience with personalistic and anthromorphic meanings.

Our present inquiry is primarily directed to an examination of such meanings as they may vary among different kinds of individuals or as they relate different qualities of personality and temperament. Our study will be reported in terms of four separate experiments. The first of these is directed toward the study of the associations which children hold for these primary digits for the purpose of exploring differences related to mathematical ability, to differential talent in mathematics, to sex and to age. This may be regarded as the primary focus of our inquiry. Our second study consists of an examination of three bodies of data on number associations obtained from American, Italian and Danish adolescent school children. The purpose of this study is to explore the possible universality of certain patterns so conspicuous in the American sample. Our third study deals with an adult sample and related attitudes toward numerals to certain higher level measures of personality and temperament obtained from independent tests. Finally, our fourth study, of least importance, represents the association of colors with numerals within a substantial population of college students.

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[1] In an effort to obtain associations to numerals purely in terms of their configurational properties, we engaged in a minor experiment with preschool children. Our procedure in this instance consisted in presenting the child with metallic numerals approximately three inches high in a random display and inviting them to select those appropriate to the concept, i.e., Friendly-Unfriendly, Boy-Girl, etc. The results can only be described as random and chaotic, and we must conclude that these preschool children were not sufficiently developed to properly engage themselves in the task. A truly fair study of this dimension of physiognomic meanings of numerals would probably require the use of a mature population from a non-Western culture.

STUDY I. A STUDY OF CHILDREN'S QUALITATIVE ASSOCIATIONS TO NUMERALS.

In an earlier study with Rachel Chen (1) it was demonstrated that among college students there is a substantial consensus concerning the attributes to be ascribed to the Arabic numerals. Thus, for example, she showed that odd numbers are generally judged to be masculine and even numbers feminine, that the number "8" is most frequently judged to be like the mother and "9" the father, that two general principles seem to be involved in the ascription of attributes to numerals, namely, a linear principle of Power in which "1" is weak and "9" is strong, and another principle we shall call the principle of Alternation in which even numbers are counterpoised to odd numbers. This principle is most commonly invoked by descriptive evaluative qualities such as Good-Bad, Friendly-Unfriendly, etc. Miss Chen's work left unanswered several very important questions to which our inquiries are directed, among them the following:

1. Whether such associations were an aid or an impediment in the manipulation of arithmetical manipulations;
2. Whether there are differences in the performance of the two sexes;
3. At what age associations become manifest and whether they increase or decrease with age;
4. Whether persons of high arithmetic and mathematical ability differed from incompetents in their pattern of associations;
5. Whether persons especially gifted in mathematical skills differed from persons with distinctive excellence in verbal skills.

Methods and Procedures: The subjects in this experiment constituted three groups of students approximately equally divided by sex from Grades 4, 7 and 10 in the Middletown school system. Table 1 shows the number of individuals in each grade by sex. For each individual

Table 1. Number of Individuals in each grade by sex.

	Grade 4	Grade 7	Grade 10
Boys	46	46	48
Girls	44	43	49
N	90	89	97

we obtained their most recent Iowa Test of Basic Skills score on verbal and mathematical abilities taken shortly before the administration of our instrument. These scores enabled us to obtain two measures on each individual, first the level of his performance in

mathematics as such, and secondly a "discrepancy" score indicating his relative attainment in mathematics as compared with verbal skills. Thus, for each individual we obtained five independent measures: grade, sex, mathematical achievement, and the "discrepancy" score expressing differences in levels of mathematical and verbal achievements. Each of these individuals was then administered our testing instrument which required them to select three digits most descriptive of ten pairs of antithetical attributes as developed by Osgood in his semantic differential (2). We also required them to specify the digit they felt most symbolic of their father, their mother and themselves. A copy of this testing instrument with the instructions is to be found in Appendix A. It should be observed that in all instances the instructions were read aloud and were also available for the scrutiny of the subject, and also that no time limit was imposed for the completion of the test, though it rarely took more than ten minutes.

The analyses of the resulting data was accomplished by obtaining the frequencies with which different numerals were ascribed by all subjects to the twenty paired qualities and the three personal figures suggested. These frequencies were next broken down by grade level, by sex, by ability score and by discrepancy score. Finally, further breakdowns were accomplished in some instances where indications seemed promising.

Results: The presentation of results from this experiment could well occupy 50-60 pages of tables, graphs and other such materials. It may be recalled here that we have four independent variables against which we are comparing the individual's performance on ten semantic scales (2) and three personalistic scales. The total number of responses from each individual is accordingly 63, and the number of our subjects is 276. Moreover, this data can be brcken down both with respect to our four independent variables and with respect to the thirteen dimensions of meaning that we are exploring. In the interest of economy, therefore, we are going to present here the composite response patterns for all subjects, identifying from among them the patterns of consensus already described, namely the Power pattern and Alternation pattern. Thereafter, we shall proceed successively to treatment of breakdowns with respect to our four independent variables, and to such further secondary breakdowns as may be deemed appropriate.

Let us now consider the overall responses to the semantic scales by our school subjects.

1. Happy-Sad. The composite results (combining all grades and both sexes) are represented in Figure I. It will be seen that here the principle of Alternation emerges with striking consistency. Happy numerals are even, Sad numerals are odd. There is virtually no evidence that the Power gradient relates to this semantic continuum.

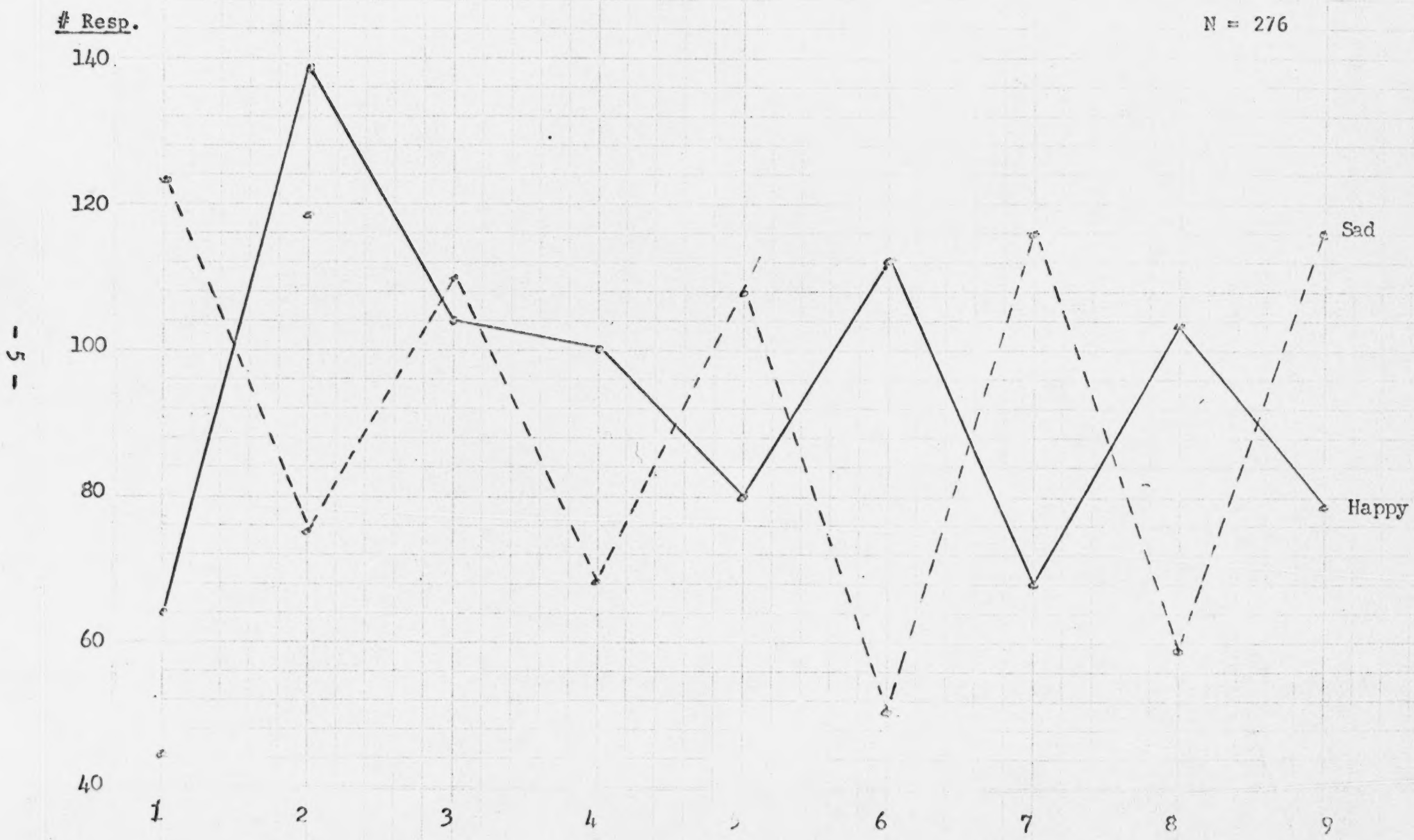

Figure I.

2. Lucky-Unlucky. The results here are remarkably similar to those reported immediately above for Happy-Sad, and are shown in Figure II. Again the principle of Alternation seems dominant and no evidence of the Power gradient can be adduced.

3. Boy-Girl. The composite results in Figure III tend to conform in general with the principle of Alternation, but it will also be observed that there is a Power gradient, such that larger numerals are ascribed to boys and smaller numerals to girls. It is clear that here both principles of Power and Alternation can be invoked to explain our results.

4. Powerful-Weak. Here, as shown in Figure IV, the Power gradient is overwhelmingly evident and the principle of Alternation virtually indiscernable.

5. Good-Bad. The pattern here (see Figure V) is remarkably uncomplicated and conforms almost purely to the principle of Alternation. The pattern is remarkably similar to that obtained for the adjectives Happy-Sad.

6. Rough-Smooth. In this instance, as with the Boy-Girl dichotomy, our principles of Power and Alternation cooperate to determine the results as shown in Figure VI. Thus, while odd numerals are judged Rough, this quality also tends to be ascribed to larger numerals. Smoothness is ascribed, on the other hand, to smaller and even numerals.

7. Friendly-Unfriendly. Like those for Rough-Smooth, these results demonstrate the operation of both the Power and Alternation principles. But the Alternation principle is here more incisive and the Power gradient less in evidence. The results may be seen in Figure VII.

We may now turn our attention to the numerals selected as descriptive of Mother, Father and Self, which we refer to as the personal identification of the numeral. The proportion of selections for each of these three persons is seen in Figure VIII. It will be seen that there is a very strong consensus favoring "9" as the most appropriate numeral for Father, this exceeding by almost five-fold the incidence of any of the other digits. The selection of "9" to represent the Father, it may be said in passing, is remarkably consistent in both sexes and for all grades, and even demonstrable, as we shall see, across national cultures.

Less incisively, the digit "8" is preferred for Mother, with only "2" offering any competition. The preferred digit for Self, on the other hand, does not show the same high degree of concentration which we have noted for Father and Mother. The digits "3" and "7" are the most commonly preferred, but, as we shall see shortly, this varies significantly with age and also to a lesser extent with sex.

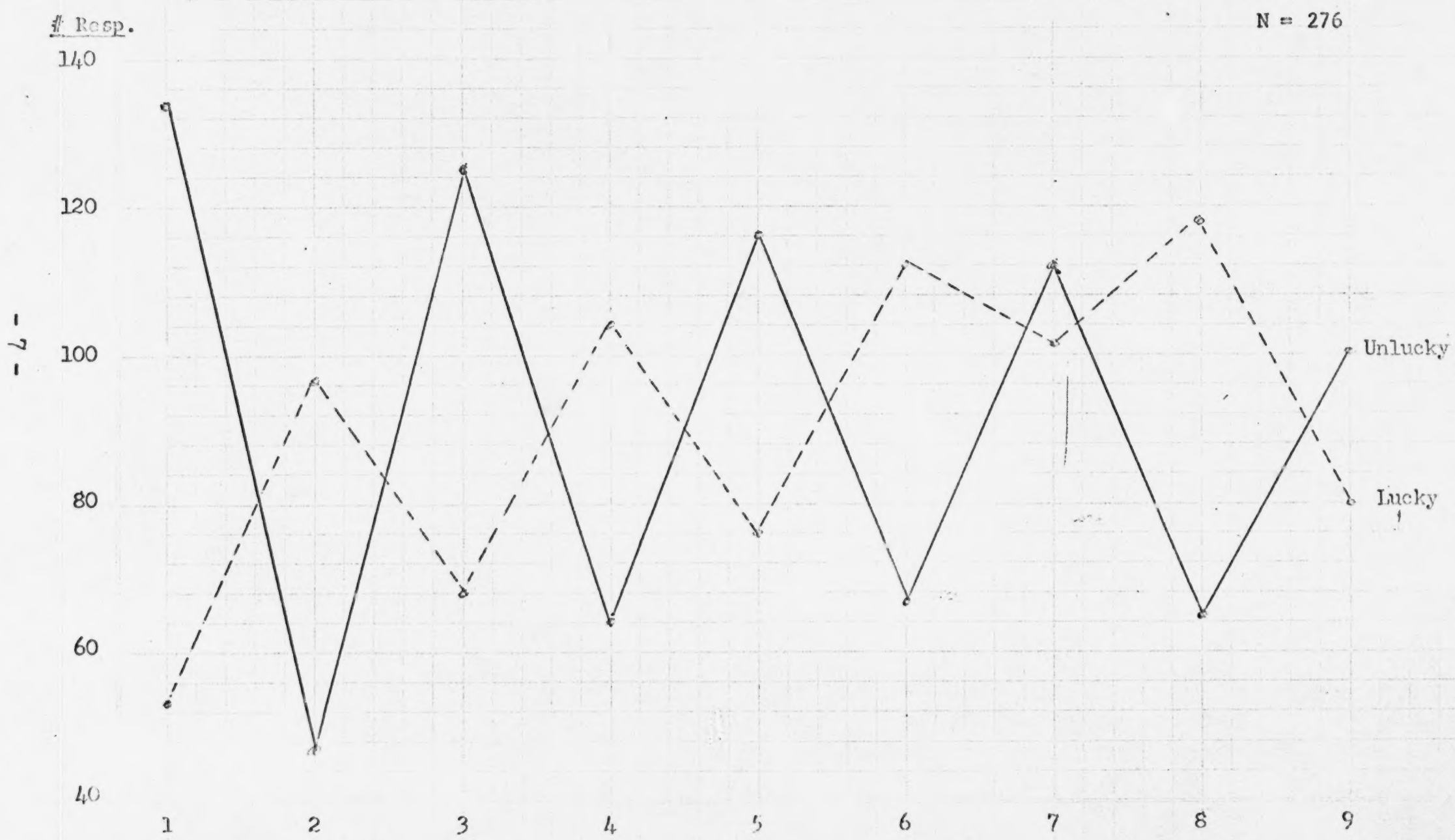

Figure 11.

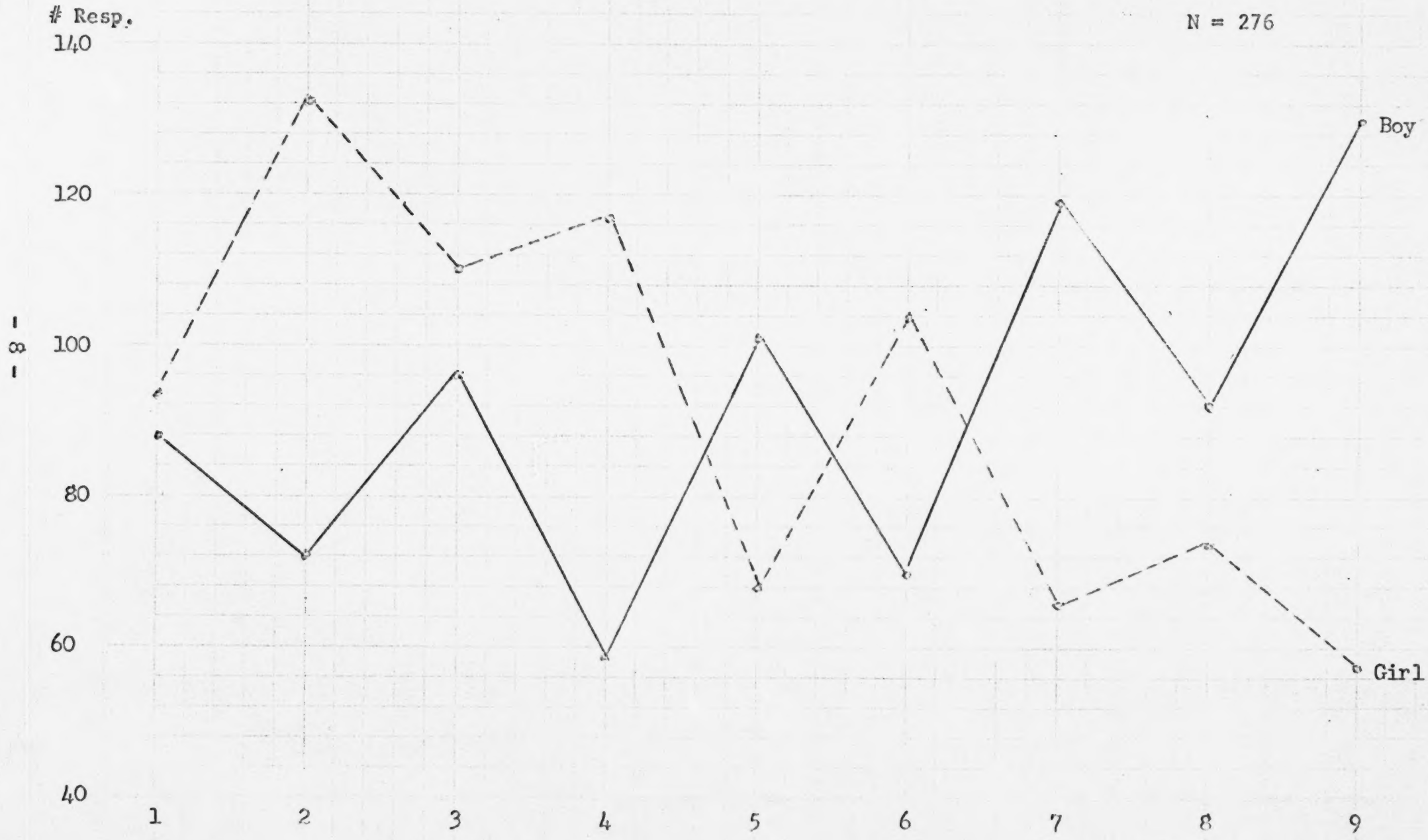

Figure III.

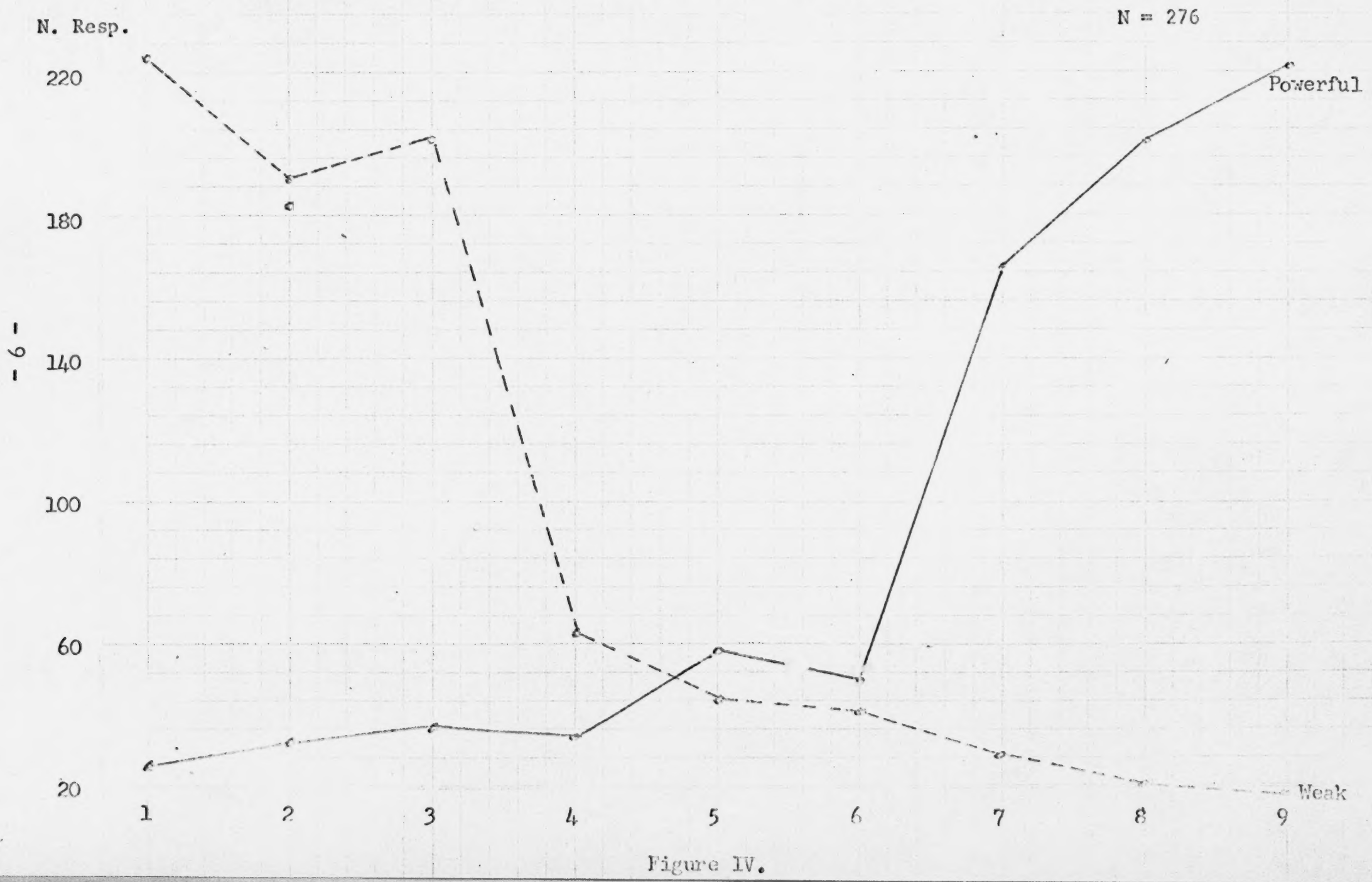

Figure IV.

N. Resp.

N = 276

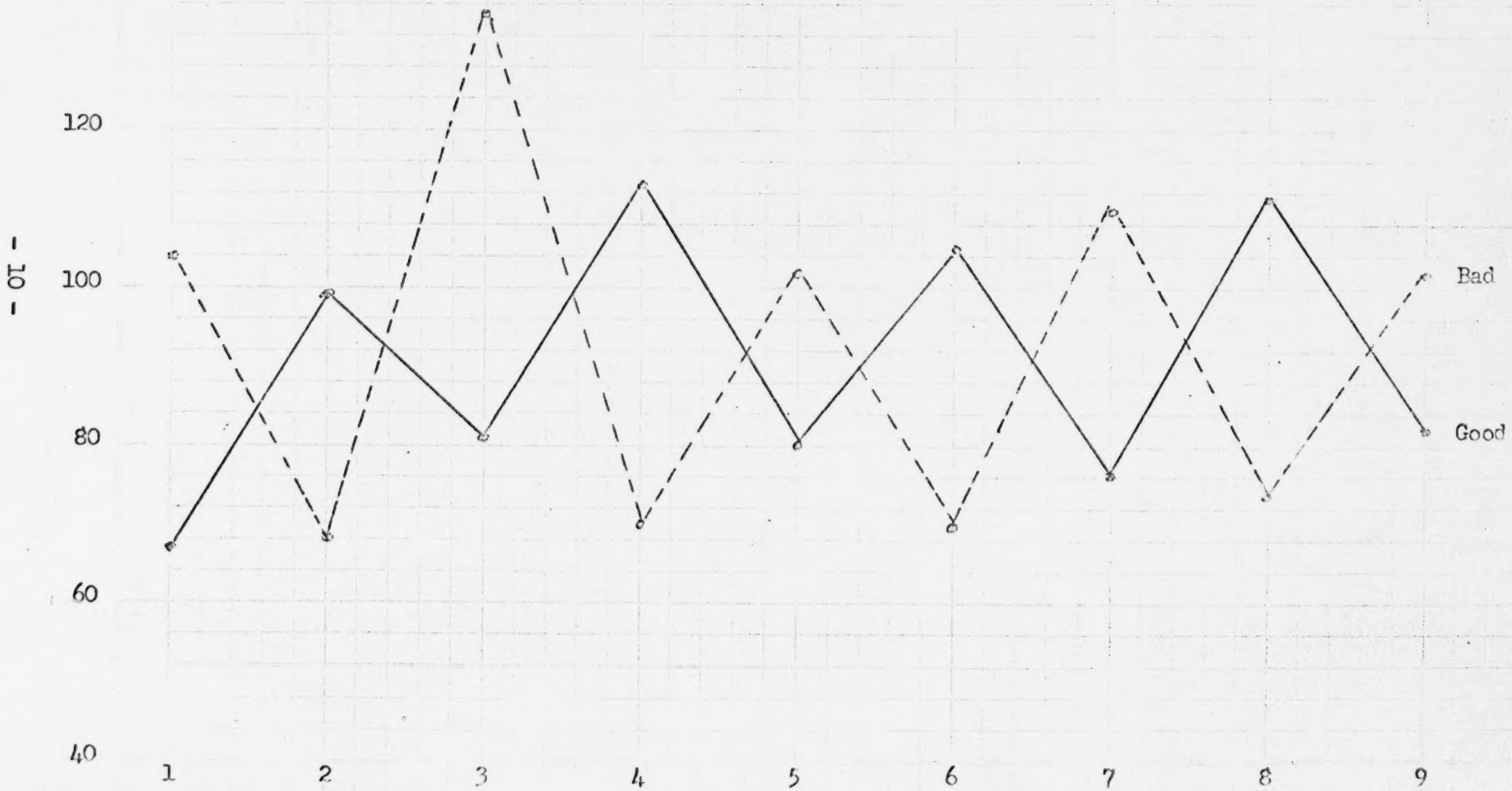

Figure V.

N. Resp.

N = 276

180

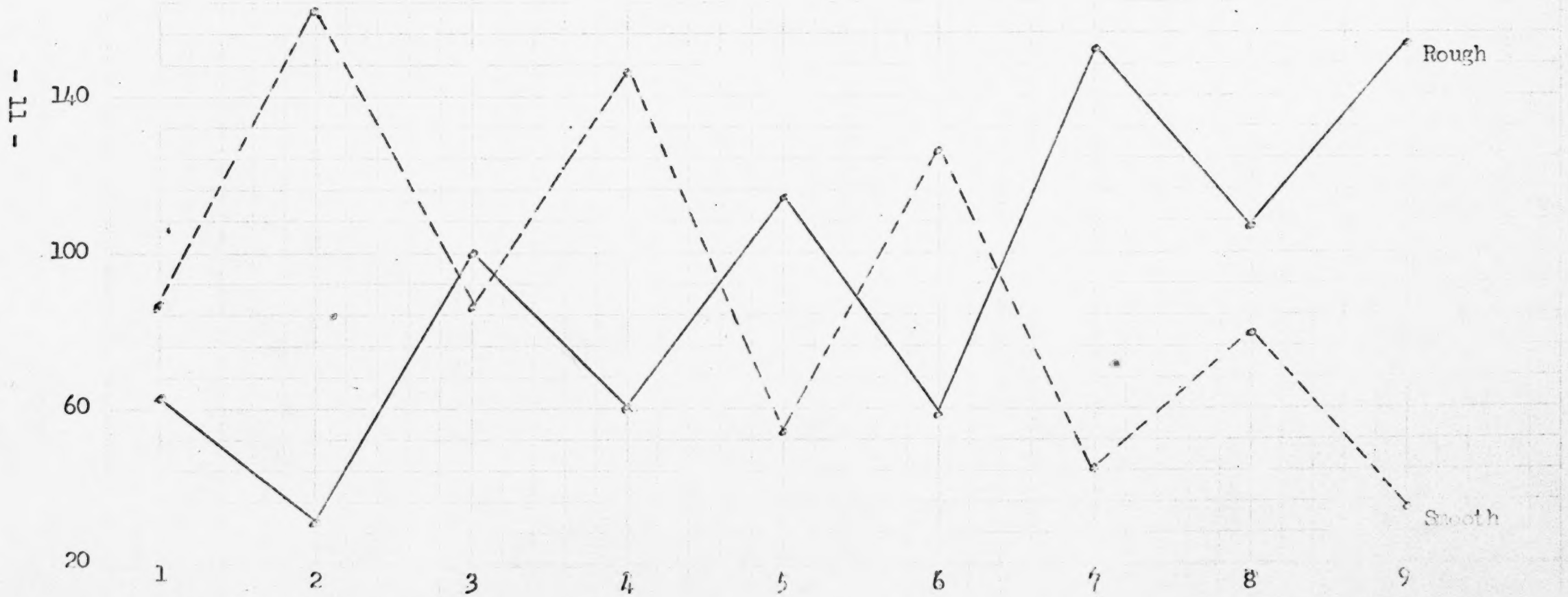

Figure VI.

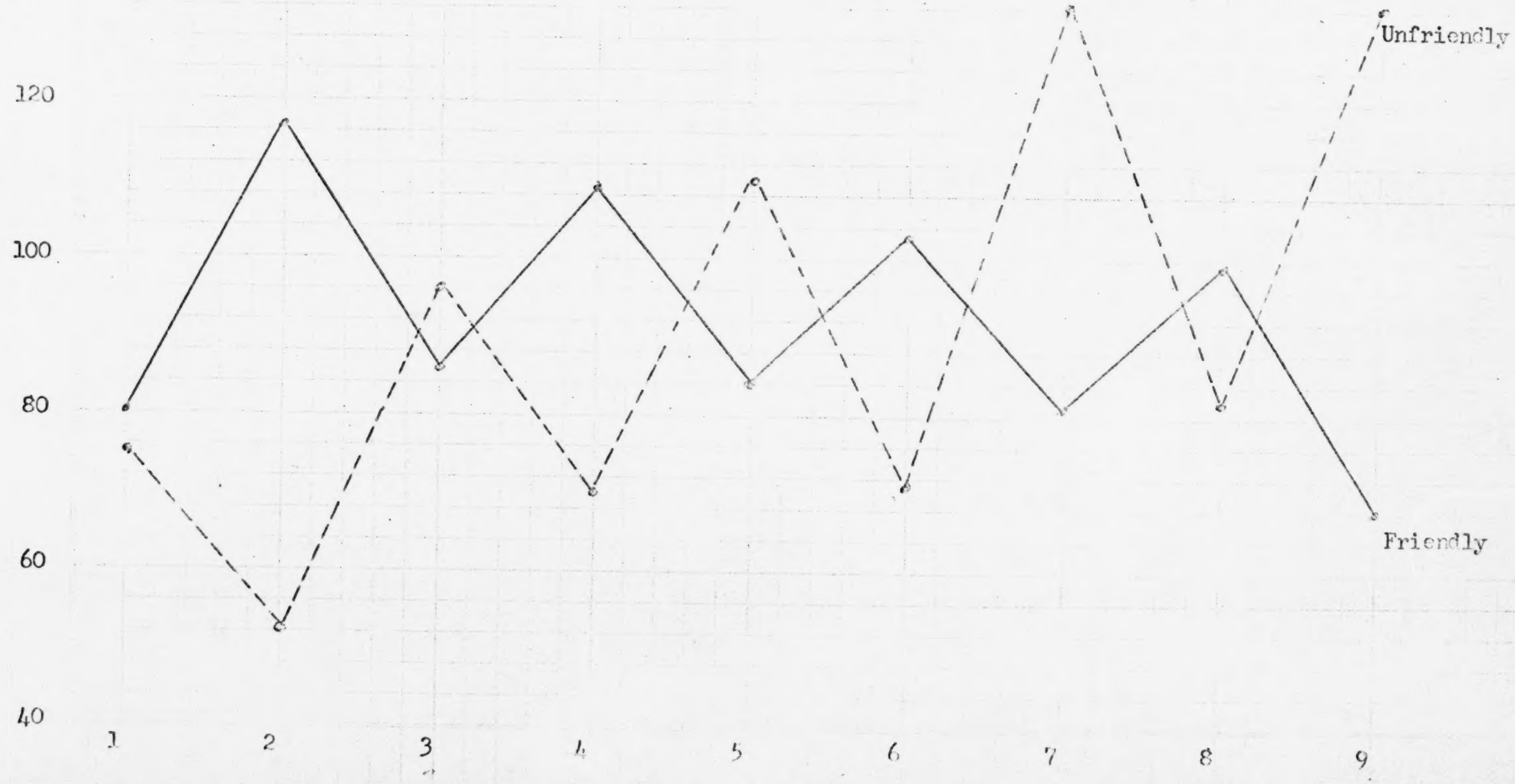
N.Resp.
140
120
100
80
60
40
N = 276
Unfriendly
Friendly
1
2
3
4
5
6
7
8
9

Figure VII.

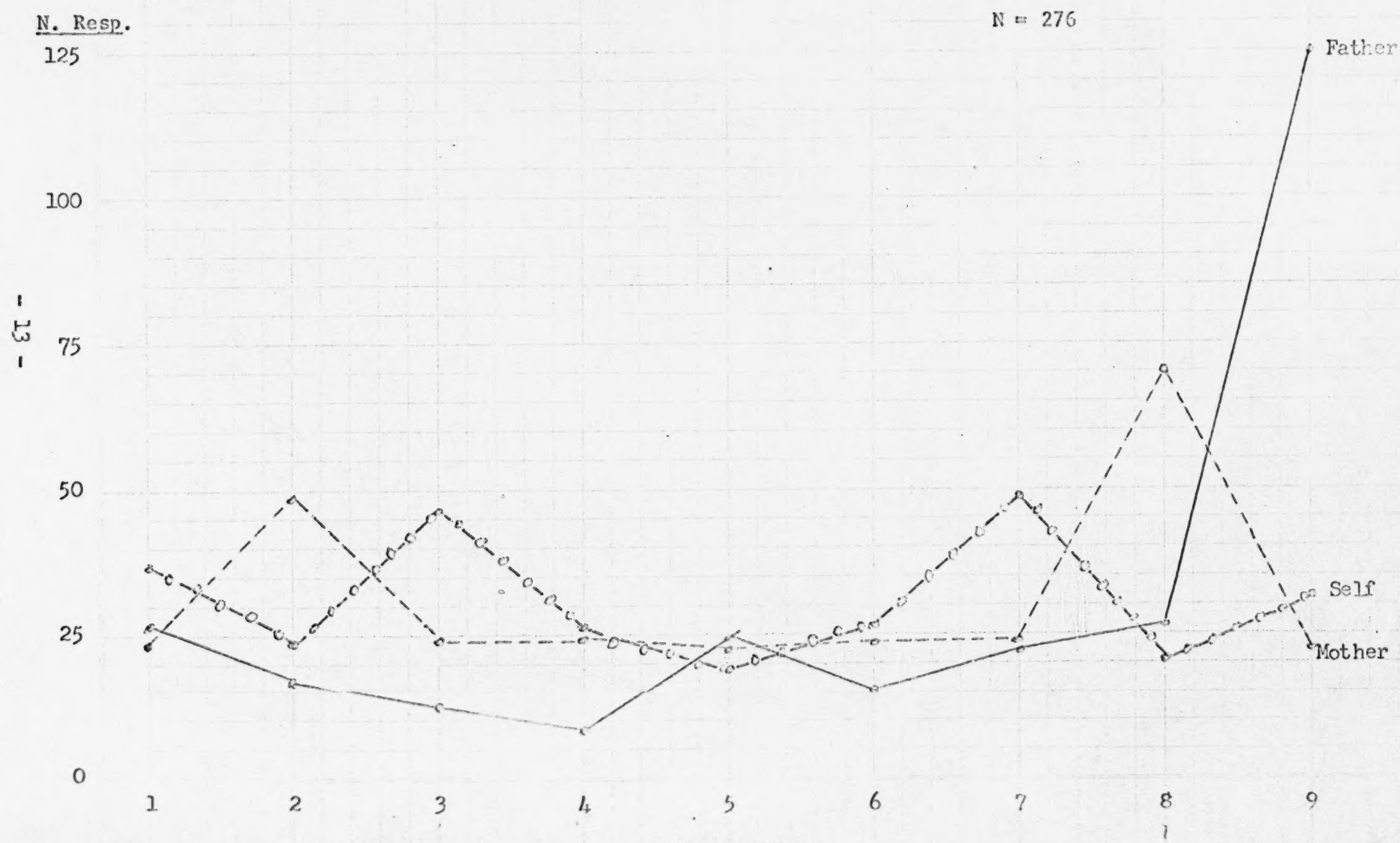

Figure VIII.

Let us now proceed to an examination of a breakdown of these composite results with respect to our four independent variables, namely, sex, grade, mathematical ability score, and discrepancy. We shall describe our results in these breakdowns in terms of conformance with or departure from the composite tendencies just noted and represented in our eight figures.

A. Sex differences.

Our first breakdown is in terms of the sex of the respondent. In the three grades (4, 7, 10) there are a total of 136 girls and 140 boys. The performance of the two sexes on our ten semantic scales and three personal identification follows.

1. Happy-Sad. In both sexes the principle of Alternation is striking in the results obtained. There is no conspicuous difference between the results from the two sexes.

2. Lucky-Unlucky. The performance of boys and girls is undistinguishable and in both instances conforms to the general principle of Alternation. There is a suggestion that on particular digits such as "3" and "4", boys are more incisive than girls.

3. Boy-Girl. There is an important and highly distinctive difference between the two sexes on this semantic dichotomy. The female data conforms to a simple principle of Alternation, such that Boys are assigned odd numerals and Girls even numerals to a consistent and striking degree. The boys, on the other hand, interpret this dichotomy primarily in terms of the Power gradient and only secondarily in terms of the Alternation principle, assigning higher numbers to Boys and lower numbers to Girls.

4. Powerful-Weak. The Power gradient is the overwhelming principle describing the results obtained, and no sex differences are to be noted.

5. Good-Bad. The results obtained from the two sexes are generally very similar and conform to our Alternation pattern, even numerals being Good and Odd numerals Bad. There are minor sex differences to be observed in passing. Thus, girls rate "2" as overwhelmingly Good, whereas boys are indecisive. However, girls are indecisive in the classification of "3" whereas boys rate it overwhelmingly Bad.

6. Rough-Smooth. In the main, the principle of Alternation holds for both sexes, Smooth numerals being even and small, Rough numerals being large and odd, thus demonstrating that both Power and Alternation principles are involved. But the data clearly suggests that the Power principle is a more significant determinant for male subjects than for female subjects.

7. Friendly-Unfriendly. The results for this semantic continuum are remarkably similar for both sexes and warrant no special comment.

8. Mother - Father - Self. The ascription of personal identity to our nine numerals by the boys and girls deserves no special comment, save that boys seem to ascribe "9" to Father and "8" to Mother with greater incisiveness than do the girls. But for both sexes this is a conspicuous and significant result. The numeral ascribed to Self varies with age. But the composite for the two sexes still deserves comment here. Boys tend in a striking degree to select an odd numeral for self-description, the most preferred being "7" and thereafter "3", "1" and "9". Girls, on the other hand, show a less clearcut pattern which does not reduce itself to any simple principle.

B. Grade Differences.

Our second breakdown is in terms of the school grade of our subjects who were selected as earlier noted from Grades 4, 7 and 10.

1. Happy-Sad. The Alternation principle is the dominant rule describing the results for this continuum for all three grades. But it may be observed that it is not so incisive for Grade 4, suggesting that these children have a less clear conception of the qualitative characteristics of numerals, and, unlike the other two grades, consider "9" a Happy numeral. It may be further noted in passing that Grade 10 rather atypically considers "3" a Happy numeral with which they predominantly identify.

2. Lucky-Unlucky. The results obtained from Grades 7 and 10 are remarkably similar and conform to our pattern of Alternation quite incisively. The same principle holds for Grade 4 but again in a more attenuated form.

3. Boy-Girl. The principle of Alternation is evident with occasional exceptions in the data at all three grade levels, though perhaps more strikingly in Grades 7 and 10. In the data from Grade 10 there is a significant negative Power gradient associated with "Girl" which is absent in the Grade 4 data. Older students also show a clear preference for smaller digits, namely "1", "2", "3" and "4", for describing both Boy and Girl concepts.

4. Powerful-Weak. This continuum requires virtually no comment since the results from all three grades are remarkably similar and conform to the Power gradient that we have already abundantly described.

5. Good-Bad. The results here present an interesting challenge. For Grade 7 and 10 students the principle of Alternation prevails in a simple form. For Grade 4 students, however, there is

in addition to the principle of Alternation a clear tendency to ascribe Bad to small numerals and Good to larger numerals.

6. Rough-Smooth. For all three grades without notable differences the results show evidence of the combination of both the Power principle and the Alternation principle as in the composite results.

7. Friendly-Unfriendly. Both the Power gradient and the principle of Alternation holds incisively for Grades 7 and 10 and in a more attenuated form for Grade 4. All three grades, in the main, however, conform with the composite results already reported.

8. Father - Mother - Self. The numeral selected for identification with these persons seems to undergo some rather significant changes with age. Well over one-half of Grade 4 identify "9" as Father, while this proportion drops to less than one-third in Grade 10. The identification of "8" with Mother shows a strong preponderance of over one-third in Grade 4 but falls off to less than one-fourth in Grade 7 and only one-seventh in Grade 10. In this last grade numerals "1" and "2" are more often selected for Mother identification than "8". Finally, we may observe that the numeral selected for Self appears to shift rather strikingly. Those in Grade 4 select numerals "7", then "9" as most preferred and constitute almost one-half of all choices. In Grade 7 there appears to be only a random pattern, but by Grade 10 the numeral "3" is overwhelmingly preferred. We shall not attempt to interpret this shift here, though we believe it has deep-lying significance as a projective explanation of the different self-images harbored by these different age groups.

C. Mathematical Ability.

Here we will report the results obtained from a breakdown of our data into four quality groups of approximately equal size, based upon their performance on the Iowa Test of Basic Skills. This procedure involved the pooling of common quality levels from our three grades. Unfortunately 16 subjects had to be dropped for lack of criterion scores. It should be said at the outset that in the main it proved very difficult to discern any linear trends in response tendency proceeding from Group 1 through Group 4.

1. Happy-Sad. There is no linear significant trend to be noted. The Alternation pattern is generally, if irregularly, sustained throughout the four groups.

2. Lucky-Unlucky. No reliable trends from Groups 1 through 4. The general principle of Alternation was sustained with positive Power gradient weakly discernable for Lucky, negatively for Unlucky.

3. Boy-Girl. There is no consistent reliable trend shown from Groups 1 through 4.

4. Powerful-Weak. Consistent and indistinguishable results typical of the composite results are found at all ability levels.

5. Good-Bad. Group 1 appears to be distinguished from Groups 2, 3, and 4 by a particularly level spectrum in the assignment of numerals to the quality Good. For the lower quality groups the Alternation principle emerges conspicuously. The same distinction appears to hold less strikingly for the assignment of numerals to the quality Bad. Our top quality group in mathematics shows the principle of Alternation here only for the first four digits, and thereafter in an essentially flat spectrum.

6. Smooth-Rough. The trend here, while not conspicuously linear, strongly suggests that the first quality group is less likely to assign a Power gradient to the attributes of Rough and Smooth than are the inferior quality groups 2, 3, and 4. The evidence of a Power gradient is barely discernable in data from Group 1.

7. Friendly-Unfriendly. On this dimension there is only a slight suggestion of a more conspicuous Power gradient as we move from Groups 1 to 4 in mathematical ability.

8. Father - Mother - Self. We now turn our attention to the personalistic identifications with numerals on the part of our four quality groups. There is a fairly clear suggestion that "9" is assigned to Father and "8" to Mother with greater consensus by our lower ability groups than by our top group. Beyond this observation there appears to be little to distinguish our four quality groups.

D. Discrepancy Scores.

The dependent variable in this instance is the discrepancy between the verbal and mathematical scores for each subject on the Iowa Test of Basic Skills. We have taken this as a measure of the degree to which the individual holds a special predeliction and capacity for arithmetical as opposed to verbal capacities and attainments. We have divided our subjects into four groups within each grade level, group 1 representing those in the highest quarter of mathematical ability in comparison with verbal ability. Group 4 represents those individuals, on the other hand, with conspicuously high verbal ability and relatively low mathematical ability. Let us now turn to the evaluation of our seven semantic scales and three scales of personal identification.

1. Happy-Sad. There is no discernible linear trend emerging from the examination of Groups 1 through 4. The principle of

Alternation here, if weakened, is generally sustained at all levels.

2. Lucky-Unlucky. There is no discernible difference between Groups 1 through 4.

3. Boy-Girl. The principle of Alternation generally prevails in this data with a suggestion that a secondary Power gradient is more evident for Group 1.

4. Powerful-Weak. There are no discernible differences between the four discrepancy groups on this variable.

5. Good-Bad. There is no discernible difference in the performance of the four groups.

6. Rough-Smooth. There appears in this instance to be a probable significant difference from the first through fourth group which is more or less linear. Group 1 in contrast to Group 4 shows a significant Power gradient with Rough assigned to larger digits, Smooth to smaller. This is virtually absent in the data obtained from Group 4, though in both groups the Alternation principle is also clearly manifest.

7. Friendly-Unfriendly. There is no discernible difference to be found in the examination of data from the four groups.

8. Father - Mother - Self. There are no significant or even suggestive linear trends to be found in this data.

Discussion: From the foregoing it can be seen that American school children varying in age, sex, mathematical ability and varying in attainments in mathematical and verbal skills tend to yield remarkably similar associations to our primary Arabic numerals. The search for differences in the association of children varying in these dimensions has not been richly productive. We may perhaps profitably divide our discussion into the results obtained from the seven semantic scales and those devoted to personal identification.

The semantic scales, as we have seen, tended to be dominated by the two principles, Power and Alternation. We were able to demonstrate some fairly significant variations in the employment of the se principles as a function of sex and also of age of respondents. But ability level in mathematics and "discrepancy" scores brought us very small return indeed. It appears to the writer that the association of qualitative attributes with numerals can be but distantly related, if at all, to actual mathematical or arithmetic prowess. This suggests that such associations in general cannot be considered to either impede or facilitate mathematical performance significantly, and it also suggests that the existence of these associations might be positively exploited for mnemonic and didactic purposes.

The data from the personal identification scales again show small relation to the ability or "discrepancy" scores, though some highly suggestive patterns with respect to age and sex emerge. This suggests that though we began this inquiry hoping to determine if such associations were related to arithmetic prowess or deficiency, we have discovered a projective device that may be of significant utility in personality research. Thus, for example, the change in the self-identification number with age and the attenuation of consensus on parental numerals from Grades 4 to 10 is highly suggestive. It is also most provocative to observe that "9", so overwhelmingly selected as the digit symbolizing the male parent, is further described with consensus as powerful, rough, unlucky, sad and unfriendly. The Mother numeral, namely "8", on the other hand, shares the quality of power but is otherwise described as smooth, happy, lucky and friendly. It is also true that qualities of self image can be inferred by induction from examining the attributes assigned to the numeral selected for self identification. In this connection the predominance of the numeral "3" for our adolescent sample is probably noteworthy, since "3" is also described as unhappy, weak and bad.

Thus, though we have failed to demonstrate a meaningful relationship between associations with numerals and arithmetic attainments, we have proven a widespread consensus in the interpretation of numerals and the fact that variations within this consensus may be related to significant personality dimensions.

Conclusions:

1. There appears to be a widespread and generally consistent agreement on the semantic qualities and personal identifications of Arabic numerals among American school children of both sexes and varying ages.

2. Variations within this consensus are most conspicuous between sex and age groupings.

3. Differences in the association patterns of students of different degrees of mathematical attainment are slight and uncertain.

4. Individuals particularly able in mathematics are largely indistinguishable in their associations to numerals from individuals notable for their verbal excellence.

5. Results deriving especially from the personal identification scales suggest that this material is capable of projective interpretation and offers the possibility for developing a personality test of some value.

6. Since there appears to be no clear advantage or disadvantage associated with the attribution of qualitative and personal qualities to numerals, it may prove that the deliberate employment of such may serve as a pedagogical and mnemonic aid in the learning of these symbol systems in childhood.

Summary: A substantial sample of school children, approximately equally divided by sex, from Grades 4, 7 and 10 were administered a test requiring them to ascribe to Arabic numerals semantic and personal qualities of a non-quantitative nature. The children were also classified according to mathematical attainment and the degree to which their mathematical attainment exceeded or fell short of their verbal attainment. The analysis of data obtained from these subjects indicated a powerful and overwhelming consensus throughout both sexes, all ages, ability groups and "discrepancy" groups. Meaningful departure from consensus was primarily to be demonstrated in connection with age and grade differentiation, and not with respect to ability level or "discrepancy" score. This suggests that such qualitative associations might be deliberately employed to pedagogical advantage in the learning of numerals and in the development of elementary arithmetic skills. The study of discrepancies in association correlated with age and sex suggests the possible development of a significant and valuable projective test.

STUDY · II. COLOR ASSOCIATION TO NUMERALS.

In the foregoing section we have demonstrated that there is fairly wide consensus concerning the semantic and personalistic attributes assigned to Arabic numerals. In the present inquiry we are to examine data assembled from 238 freshmen from the Wesleyan class of 1967 in which they indicate their color associations with numerals. It was our general hypothesis that even numerals ought to be associated with passive colors such as blue or green and that odd numerals ought to be associated with reds and other warm colors. Such a hypothesis grows out of the distinction made by Koffka between hard and soft colors, i.e., red vs. blue. Thus, masculine numerals which, as we have shown, are odd, should be associated with the hard colors, especially red, while feminine numerals, which are even, should be associated with blue and allied soft colors.

Methods and Procedures: All subjects were given a sheet upon which six primary and secondary colors were listed, ranging from red through to purple. They were invited to ascribe colors freely to each of the nine numerals which are the subject of examination. Thus, from each subject we obtained nine responses, or a total of 2142 from all subjects.

Results: Table 2 shows the total number of times each color was assigned to a numeral. It will be seen that blue is most frequently attributed, purple least, though all colors are employed with substantial frequency.

Table 2. Incidences of responses to employment of six colors.

Red	Orange	Yellow	Green	Blue	Purple
430	303	312	383	442	272

Table 3 presents the percentage of responses for each color ascribed to each digit. An examination of this table shows that certain colors yielded fairly distinctive patterns while others do not suggest any facile interpretation.

Table 3. Percentage of responses for nine numerals assigned by color.

	Red	Orange	Yellow	Green	Blue	Purple
1	20	4	19	6	10	4
2	9	12	11	11	17	5
3	10	17	10	17	6	9
4	8	12	10	12	16	9
5	14	11	10	10	8	13
6	8	12	13	13	11	11
7	10	10	11	12	9	16
8	9	12	10	11	14	10
9	11	10	8	9	9	24

Thus, red tends to be ascribed to odd, not even, numbers. On the null hypothesis, we would expect the even numbers to claim 44% of the responses, or 4/9. In fact, they claim but 34%, while 66% of the red responses are ascribed to odd numbers. The principle of Alternation, which we have earlier described, is here manifest, and we may note that the identification of hard colors with odd numbers, elsewhere identified as masculine, is consistent with our hypothesis.

The ascription of orange to numerals shows a somewhat irregular pattern which does not admit of ready interpretation, though it should be noted in passing that the pattern for orange and green is remarkably similar, especially in the large number of times that these colors are ascribed to the numeral "3".

Yellow, like red, is notable for the number of times that it is ascribed to "1", but beyond this no significant observation seems possible. In the case of blue, there is a very incisive and striking pattern in which our Alternation principle is distinctly manifest throughout. Thus, even numbers are persistently ascribed to this color, odd numbers much more rarely. We would expect on the null hypothesis that 56% of our responses would be ascribed to odd numerals. In actual fact, the odd numerals claim but 42%. This result conforms entirely to our earlier hypothesis that soft colors should be ascribed to feminine numerals.

Finally, there is the interesting case of purple in which we may note that this is conspicuously the preferred color ascribed to "9". It will also be recalled that "9" was notable for the degree to which it was selected in our earlier study as symbolic of the male parent. Thus, the association of masculinity and power with purple seems sustained both here and in traditional lore.

Discussion: In the foregoing we have been able to show that while the identification of color with numerals is probably less incisive than the identification of personal identities or qualitative attributes, still patterns do emerge here with genuine consistency. Our hypothesis that hard and soft colors should follow the principle of Alternation in their ascription to numerals is generally sustained in the case of red and blue, the two purest examples of hard and soft colors, respectively. The seeming identification of purple with power is statistically incisive. It would appear that the ascription of this color to numerals is dominated by the power gradient. These findings may be taken as still further confirmation of the general proposition that numerals are endowed with trans-quantitative attributes of a complex and affectively freighted significance.

Conclusions:

1. The ascription of colors to numerals tends to show certain patterns in conformity with the hypothesis that "hard" colors will be associated with odd numerals, soft colors with even numerals. This expectation is particularly sustained in the data obtained for the ascriptions to red and blue, respectively.

2. The ascription of purple is noteworthy for the degree to which it is ascribed to large numerals, especially "7" and "9", which are elsewhere demonstrated to be associated with power and masculinity, thus confirming popular associations and lore respecting this color.

3. The pattern of ascription to numerals of orange, yellow and green proves less incisive, save that the first two colors are notably ascribed to the numeral "3" for reasons not presently clear.

Summary: Two hundred thirty-eight male college students were required to indicate which of six colors, primary and secondary, they identified with each of the numerals 1 thru 9. It was our hypothesis that "hard" colors, notably red, would be ascribed to odd numerals, which in the previous studies proved to be masculine. It was, on the other hand, hypothesized that blue would be ascribed predominantly to even numerals. These general expectations were sustained in the results, especially in the ascription of blue to even numerals. Beyond this, it is to be noted that purple is pre-eminently associated with "9" and follows a declining gradient in general to the numeral "1", while the pattern for orange, yellow and green, while not random, does not offer any simple principle of explanation. Thus, the specific hypothesis that "hard" and "soft" colors should be ascribed to odd and even numerals, respectively, receives substantial confirmation. More generally, the proposition that numerals are the bearers of non-quantitative attributes, concerning which there is substantial consensus, is here demonstrated.

STUDY III. THE PERSONALITY CORRELATES OF PERFORMANCE ON TESTS INVOLVING ARABIC NUMERALS.

In an earlier study by Miss Rachel Chen and the writer (3) efforts were made to correlate preference for numerals, spontaneous production of numerals, and associations with numerals, with personality dimensions, among them the Myers-Briggs Type Indicator. Correlations in this study suggested that a further examination might be made of numeral preferences and associations in relation to the Myers-Briggs Type Indicator and certain other personality measures. Accordingly, in the present research we have evolved 9 measures of spontaneous attitude toward, or performance with, numerals. These 9 dependent variables are correlated with the four scales of the Myers-Briggs Type Indicator and with the IPAT Self Analysis Form (Anxiety). It was our hypothesis that performance on our various tests involving numerals would correlate with certain temperamental predelictions and intellectual dispositions of the individual represented by these personality scales. We further surmised that our results would not be inconsonant with suggestive findings reported in Miss Chen's study.

Methods and Procedures: The subjects in this experiment consisted of 90 summer school students, all of them teachers at the primary and secondary school level, of whom a substantial proportion were particularly interested in science and mathematics. Fifty-two of these were female and 38 male. Their services were obtained in response to advertisements, and they were remunerated for their service. We hoped by this device to obtain a more dedicated address to our problem than Miss Chen had received from her college freshmen in the earlier study alluded to.

Three tests involving the implementation of numerals were administered to each subject, and the scores evolving therefrom may be considered our dependent variables. The first of these tests required the subject to produce spontaneously and, so far as possible, randomly, a series of numerals numbering 144. The instructions required that the subject proceed as rapidly as possible, avoiding any sequential patterning. The second test involved the ascription of semantic qualities to the nine Arabic numerals excluding zero. This constituted, in essence, the same test procedure reported in Study 1 of this report. The third test required the individual to identify the numeral most like himself, least like himself, most like his mother, least like his mother, most like his father and least like his father.

The scoring of the first test of spontaneous production of numerals yielded 2 measures: 1) the sum of all even numerals, which could be interpreted immediately as the preference of even over odd numerals or vice versa; 2) the preference for powerful numerals

(7-8-9), expressed as the sum of numerals 1-2-3 divided by the sum of 1-2-3 and 7-8-9. The resulting score indicated the disposition to prefer, in spontaneous production, small over large numerals, as will be seen.

Our second test involved the employment of nine bi-polar adjectival semantic scales, and from performance on this test we obtained four measures as follows: 1) an alternation score expressing the degree to which a person tended to employ the principle of even or odd numerals as a basis for ascription to the adjectives employed; 2) a measure of the degree to which the power gradient, elsewhere described, constituted the primary basis for the assignment to numerals; 3) a "popular" score expressing the degree to which an individual did or did not conform to the main consensus of the group; 4) the numeral most like self, least like self, most like the father, and most like the mother. These personal identifications yielded four scores which we considered only in their quantitative aspect.

Thus, in summary we obtained two scores from the spontaneous production test, three scores from the ascription of semantic attributes and four scores representing personal identification.

In addition to these tests, we required each individual to take the Myers-Briggs Type Indicator (4) and the IPAT Anxiety Scale as developed by Cattell(5). The first of these yielded four scores measuring 1) Extraversion-Introversion; 2) Sensation-Intuition; 3) Thinking-Feeling; and 4) Judgment-Perception. The second test yielded a single score on the general anxiety level of the subject. A correlation matrix was established relating the nine dependent variables and the five independent variables all to each other.

Results: Table 4 presents the correlations between our five independent variables and the nine dependent variables. An inspection of this table will reveal that our results are quite disappointing. The tendency to produce even numerals in the spontaneous production yields positive correlations in excess of the 1% level with the Sensation vs. Intuition and Judgment vs. Perception scales of the Myers-Briggs, replicating the suggestive finding in Miss Chen's study. It comes as no surprise to observe that these two scales bear an opposite relationship to the power gradient as a principle of ascription of semantic properties. But beyond this we can make little claim for any significant findings relating our dependent to independent variables.

We have examined the correlation matrices for male and female subjects separately, though we shall not report them here

Table 4. Correlations between five independent variables and nine dependent variables.

	Even Spontaneous	Power Spontaneous	Alternation Semantic	Power Gradient Semantic	Popularity Semantic	Like Self	Least Self	Mother	Father
Extraversion vs. Introversion	-16	-03	-14	-03	+01	+05	-01	+10	-12
Sensation vs. Intuition	+30	+05	+17	-31	-04	+20	-06	-04	+12
Thinking vs. Feeling	+16	+09	+04	+01	+01	+02	+20	-18	-02
Judgment vs. Perception	+27	-03	+03	-20	+03	+11	-08	-15	+08
Anxiety	-06	-09	-05	+05	-10	+06	-05	-05	-13

5% level = .205
1% level = .267

in the interest of economy. Suffice it to say both males and females show the same correlations between the spontaneous production of even numerals and the power gradient as a principle of the attribution of numerals to semantic qualities. We find no instance of conspicuous difference or challenging discrepancy in the results obtained for the two sexes.

It should also be noted in passing, however, that we have compared the performance of males and females on all of our dependent and independent variables, and we find no instance of significant difference save in the cases of the judging-perceiving scale and the Extraversion-Introversion scale of the Myers-Briggs where the 5% level of significance is attained. Thus, our hopes of demonstrating with this group of subjects that males and females would show significantly different performance patterns on our numerical tasks is quite unsustained.

Discussion: It is difficult to say what useful discussion can evolve from the results just reported. We have confirmed in a very limited manner some of the suggestive relationships between the Myers-Briggs Type Indicator scales and attitudes towards numerals found in Miss Chen's study, but apart from this the resulting correlations are discouragingly small and the main findings of our inquiry are essentially negative. It is possible that our subjects, being teachers and frequently involved in mathematics and science, adopted certain task attitudes which obscured the tendencies and associations to be observed among a more immature or less sophisticated population. We might also, but we did not, have undertaken an analysis of the personal identification scores in terms of even/odd as well as in terms of simple quantity. But the emerging picture hardly suggests that such further examination would radically redeem the value of this inquiry. In simple language, I think this must be regarded as a promising but largely fruitless study.

Conclusions:

1. There appears to be a significant relationship between the propensity to the production of even numerals in a spontaneous series and to a disposition toward sensation and judging as measured by the Myers-Briggs Type Indicator. This finding is consistent with trends found in an earlier study and sustained in results obtained from both sexes.

2. There also appear significant negative correlations between these scales and the propensity to employ a power gradient in the ascription of numerals to qualitative semantic attributes.

3. Other correlations between our independent and dependent variables proved to be insignificant.

4. Contrary to expectation, our tests of numeral association and spontaneous production do not yield significant differences between the two sexes.

Summary: Ninety summer school students, primarily secondary school teachers, were administered three tests involving the spontaneous production of numerals and associations to numerals. From these three tests nine dependent measures were derived. In addition two standardized personality tests were administered, the Myers-Briggs Type Indicator and the IPAT Anxiety scale, yielding few independent measures. Correlations established between the independent and dependent measures were in the main of small significance. It was, however, demonstrated that the propensity to produce even numerals in spontaneous series is positively related to sensing and judging on the Myers-Briggs Type Indicator, a result confirming suggestive findings in an earlier study. A negative relationship, as might be expected, also obtained between the employment of the power gradient in the ascription of qualities to numerals and those 2 measures from the Type Indicator. Our efforts to demonstrate sex differences either in patterns of correlations or mean performance scores on our dependent variables proved fruitless.

STUDY IV. A PRELIMINARY REPORT ON A CROSS-CULTURAL STUDY OF ASSOCIATIONS TO NUMERALS.

In the first section of this study we reported the performance of American children of different grade levels in schools and of different sexes on the qualitative semantic associations which they held for Arabic numerals and also on the personal identifications which they attached to them. We were there able to demonstrate a remarkably consistent consensus both between sexes and for different grade levels. Moreover, this consensus had been shown to obtain for college students and even for mature adults within the American population examined. In the main, we were able to report that the fact of consensus was far more striking than the differences obtaining between sexes and between age groupings.

These findings actually suggested to us the possibility of exploring associations to numerals in other cultures. It proved possible to obtain through European contacts samples of Italian and Danish boys and girls of approximately the same age level as our tenth grade American sample. The main purpose of our present study, therefore, is an examination of the degree to which the patterns of consensus, demonstrated in the American sample, may also be found in those from Denmark and Italy. This necessarily involved a translation of our instrument into Danish and Italian, respectively, and in the case of Danish offered in one instance a rather special difficulty. This involved a single scale and constitutes, however, a minor problem. Fortunately, the instrument is so simple in construction and so straightforward in administration that the problem of translation into a foreign language does not loom as a likely source of experimental error.

It should be borne in mind, of course, that all three cultures, American, Danish and Italian, are essentially Western and employ the decimal system of enumeration and the same Arabic numerals with the slight difference in the representation of the numeral "7". The question may thus be raised as to whether the consensus which we shall presently demonstrate is confined to European cultures or whether it transcends these and participates in a truly international metaphorical tradition.

Methods and Procedures: Through the collaboration of associates in Florence, Italy and Copenhagen, Denmark, we were able to enlist the cooperation of a substantial number of male and female students from approximately the 16th year. Table 5 shows the numbers in the three national samples by sex. All were required to fill out our standardized semantic scales, described in the first section of this report, which are seven in number. In addition, they were asked to pick out in every instance the numeral most representative of their male parent, their female parent and finally of themselves. In the

Table 5. Numbers in 3 national samples.

	American	Danish	Italian
M	48	34	48
F	49	42	22
N =	97	76	70

results which follow, we compare results obtained from American tenth graders and from their comparable age groups in Italy and in Denmark. We are not including here for comparison the data obtained for 4th and 7th graders in the American sample.

Results: The results we have obtained from these three national samples have been reduced to composites indicating the incidence with which each numeral is identified with each of our semantic scales and with the three personal identifications earlier specified. We shall report here only our composite findings, ignoring sex differences which we have shown to be relatively slight, at least in the American sample. We now turn to results from our semantic scales.

1. Happy-Sad. In all three national groups the principle of Alternation shows conspicuously in the resulting data. There is a tendency for a negative gradient to obtain in all three samples for Happy. But for Sad there is no evidence of a gradient, excepting for the Italian sample, where the gradient is negative.

2. Lucky-Unlucky. Among all three national samples the principle of Alternation is clearly manifest. It is most striking in the American sample and perhaps least in the Italian sample. In the American sample "7", though odd, is esteemed Lucky, whereas in all other instances, in all samples, odd numbers are generally Unlucky. For some reason "8" in the Italian sample is considered to be almost uniquely Lucky.

3. Boy-Girl. The response pattern for Girl is quite consistent in all three samples. There is a clear negative gradient with a secondary principle of alternation favoring even numbers for all three groups with very minor exceptions. Similarly, in all three groups, despite the negative gradient, "1" is relatively rarely selected for the female figure. The reactions for Boy tend to show slight positive gradient in the Danish and Italian samples which is absent in the American sample. On the other hand, all three groups

show a secondary Alternation principle which is sustained with only one or two exceptions, and indicate preference of odd numbers in association with the male.

4. Powerful-Weak: In all three samples the so-called Power gradient is clearly and dominantly manifest, though this appears to be a more incisive effect in the American sample than in the two European samples. There is a slight indication in the Danish sample of the principle of Alternation such that odd numbers are considered weaker than even. This tendency is quite absent from the American sample. There is, if anything, a contrary tendency in the Italian sample, where odd numbers are judged stronger. But these observations are but minor compared with the overwhelming agreement of all three groups on the power gradient principle.

5. Good-Bad. In this instance we have two responses from our Danish sample since the word "Bad" in Danish can be rendered into the equivalent of "naughty" or "evil." Actually, the response pattern for the two does not differ in any important sense; therefore, we shall merely note this distinction in passing. The dominant principle in all three samples is that of Alternation and this probably is most striking in the Danish sample. There is no notable power gradient in the results of any group except possibly the Italians, who apparently conceive large numbers ("6" and over) as better than smaller numbers. In the American sample the Alternation principle for Bad (odd numbers are Bad) is more conspicuous than the Alternation principle for Good. This tendency is not manifest in the two European samples.

6. Rough-Smooth. The principle of Alternation is very strikingly evident in the Danish and American samples, odd numbers being Rough, even numbers Smooth. In the Italian sample this tendency is also in evidence but in a far more attenuated degree. The American sample, in addition, is characterized by a positive power gradient for Rough and a negative gradient for Smooth. Neither the Italian nor Danish data, on the other hand, show any conspicuous power gradient for either.

7. Friendly-Unfriendly. Here again the principle of Alternation is strikingly manifest in the Danish and American samples, but much more attenuated in the Italian sample. Odd numbers are deemed Unfriendly and even numbers Friendly. Again, the American data show a clear negative gradient for Friendly and a positive gradient for Unfriendly. The Danish data sustain this same tendency, but weakly, while the Italian data show a fairly incisive positive gradient for Friendly. This last observation is one of the few, and probably the most conspicuous, national differencs.

It will be seen from the above that the concurrence of the three national groups in the assignment of semantic qualities to numerals is overwhelmingly similar. Only rarely and in minor respects have we been able to observe any national differences. It would appear, therefore, that there is probably a very substantial latent consensus concerning the non-quantitative attributes of numbers in American and the two European cultures studied.

Let us now turn to the personal identifications assigned by our three national samples to Father, Mother, and Self.

1. Father. The selection of the numeral for Father is remarkably similar in the Danish and American samples. First choice is given to "9" and second to "1". In the Italian sample, on the other hand, "1" is rarely assigned to Father, whereas "8" or "9" are elected by the large majority. The ascription of "8" to Father in the Italian sample is highly distinctive, as well as their seeming reluctance to assign "1".

2. Mother. The results of the three national groups in selecting the numeral for Mother show some striking differences. In the American sample in this age group (but not for younger children) the numeral "2" and then "1" are selected, while "8" places third in order. In the Danish sample, on the other hand, "8" is overwhelmingly preferred as the Mother numeral while "8" and "9" are equally and predominantly chosen by the Italian children. Our American sample tends to be rather atypical both with respect to the European samples and with respect to younger and older American samples in the low incidence with which they assign "8" to the Mother figure. On the other hand, the fact that "8" and "9" are indiscriminately selected to represent the Mother and Father parent among the Italians is distinctive and atypical.

3. Self. The three national groups show quite distinctive and individualistic patterns in selecting the numeral appropriate to themselves. The overwhelmingly preferred numeral for American boys and girls of this age (approximately 16) is "3", whose general attributes may be readily seen from a consideration of the first section of this report. In the Danish sample there appears to be no conspicuous trend comparable to the striking result in the American sample, "5" is by a small margin most frequently chosen as the Self numeral, "2" and "8" but rarely. In the Italian sample, on the other hand, "9" and "1" are conspicuously preferred. The contrast between the Italian and the American results in the selection of a Self numeral is quite striking, but its interpretation lies beyond the scope of our present study.

It will be seen that whereas consensus was overwhelmingly evident in the assignment of semantic attributes, national differ-

ences emerge quite conspicuously in the data treating of personal identification with numerals. This result offers particular challenge in the interpretation of the cultural similarities and differences obtaining between the three groups under study.

Discussion: In the foregoing we have presented some rather conflicting evidence concerning the consensus with which numerals are viewed in their non-quantitative aspects by three national groups, American, Danish and Italian. The so-called semantic qualities attributed to numerals show, in the main, striking consistencies across cultures. Thus, such qualities as Boy-Girl, powerful-weak, rough-smooth, etc., yielded response patterns that are consistent and highly similar for all three groups. This suggests that in terms of the metaphorical symbolism of numerals there is a substantial consensus, at least within Western civilizations. That this metaphorical concurrence may also include Asiatic cultures is suggested by certain fragmentary evidence from folklore and anthropology (6).

On the other hand, there is far less consensus in our three groups in the attribution of personal identities to numerals. Thus, the American adolescent males and females tend to identify with the numeral "3" which they also describe as having the properties of weakness, sadness, misfortune, etc. The Italian sample, on the other hand, selects the numerals "1" and "9" predominantly for self-identification, while the Danes show no strikingly consistent pattern but seem to prefer the numeral "5". This last may be of no significance, but the contrast of the Italian and American samples on self identity is conspicuous. The numeral selected to represent the Mother and the Father is also by no means consistent across the three samples examined. Thus, the American sample overwhelmingly selects "9" for the male parent whereas the Italian children select "8" and "9" with almost equal incidence. Similarly, a so-called Mother numeral is not consistently selected by the three different samples. We are, therefore, led to the following tentative conclusion, namely, that the semantic qualities ascribed to numerals do indeed transcend the national cultures we have examined and are probably common to Western civilization in general. On the other hand, the ascription of personal identity to numerals varies substantially from culture to culture, depending upon the role occupied by the individual within that national culture. Thus, the discrepancies respecting personal identity may be thought of as projective expressions of role differences between cultures, while the consensus on semantic variables arises from a communality of metaphorical language.

Conclusions:

1. There is a striking consensus in our equated samples of American, Italian and Danish school children in the ascription of

semantic attributes to Arabic numerals, which quite over-rides small and occasional group differences.

2. In the ascription of personal identities (Mother, Father, Self) to Arabic numerals, there is substantial divergence between the three samples. This suggests that here projective considerations enter which reflect the differing roles and statuses of the personal identifications involved in the three cultures examined.

Summary: Three groups of students from American, Italian and Danish schools were required to indicate the degree to which Arabic numerals might be ascribed to seven semantic scales and three personal identification roles (Mother, Father, Self). The results showed a remarkable consistency of responses on the ascription of numerals to the semantic scales by all three national groups. In the ascription of personal identity, however, substantial divergences were noted, suggesting that here differing national culture and role expectations produce this result.

STUDY V. SEX DIFFERENCES IN ATTITUDES TOWARDS NUMBERS AND QUANTIFICATION.

In this final section of our report we should like to give an account of a questionnaire currently in process of development. The preliminary phase of this questionnaire was accomplished under the U. S. Office of Education contract. Its continuation and present development is being supported, however, by other funds.

The purpose of this questionnaire was to devise a series of questions which would reflect interest in, and preoccupation with, the world of numbers and quantification. We have sought here to explore the respondents' tendency to quantify their experiences to deal with quantities in preference to qualities and to fascination in the world of mensuration. We have sought to select questions which reflect the everyday experience and preoccupation of people.

In the specific results reported in this section we shall deal with the responses given by 70 male and 61 female tenth grade students. Our interest here is in exploring the differences in responses of the two sexes to the 32-item questionnaire which has been developed. It is our hypothesis that in general, where the question permits, the females will tend to indicate less interest in, and familiarity with, quantitative dimensions of experience. This hypothesis is in accordance with well-established sex differences within our culture as reflected, for example, on mean performance of the two sexes on College Board Examinations and other similar tests.

Methods and Procedures: A questionnaire of 34 items was prepared and administered to a preliminary sample of summer school teachers. On the basis of these returns two items were eliminated and several others were slightly altered in order to achieve a more satisfactory distribution of responses. The resulting revision was administered to 70 high school (10th grade) males and 61 females with the instructions that they answer all items on a five-point scale.

We have thus far explored the item difference between the two sexes and find that the following items elicit significantly greater acceptance from the male subjects at the significance levels indicated in each instance:

#5.	Do you consider that boys and men are naturally more proficient in mathematics?	> .05 level
#6.	Do you think you have a better sense of rhythm than most people?	> .07 level
#10.	Do you think you enjoy gambling more than most people do?	> .01 level

#14.	Are you generally better in mathematical subjects than in those requiring verbal skills?	> .01 level
#19.	Are you particularly skillful at guessing games?	> .05 level
#21.	Do you think you have a richer body of associations to numbers than most people?	>.001 level
#22.	Do you generally maintain your orientation with respect to North, South, East and West better than most people?	>.001 level
#26.	Do you keep an accurate account of your finances?	> .05 level
#28.	Is it especially annoying to you to have telephone numbers all in digits?	.06 level
#29.	Do you think you are a better judge of distance than most people?	>.001 level

The following items, on the other hand, elicit significantly gre ater acceptance from the female subjects:

#11.	Do you frequently count steps in a staircase just for the fun of it?	>.001 level
#13.	Do you sometimes find yourself counting cracks in the sidewalk?	> .02 level
#32.	Do you much prefer word and letter games over number games?	>.001 level

It will be observed that 11 items exceed the 5% level of significance, while seven items exceed the 1% level, out of a total of 32 items. The females are conspicuous in their acquiescence to Items 11 and 13, both of which involve repetition compulsions (steps and cracks in the sidewalk). The items which distinguish males, on the other hand, in the main express self confidence in the world of quantification. This includes, among other things, judging time and distance and even maintaining orientation with respect to the compass. It is clear from the above that sex differences in the direction of expectation are revealed in our results. It remains to be determined if this questionnaire can usefully discriminate between persons of high and low mathematical ability or between individuals of different vocational and academic interests. As a supplement, however, to the researches reported in the preceding sections, we feel this represents promising exercise.

Conclusions:

1. On a questionnaire involving attitudes towards quantification in everyday aspects of life, boys indicate a generally higher confidence in the management of quantification than do girls.

2. Girls, on the other hand, show a distinctive acquiescence to items involving the compulsive counting of repetitive physical events.

Summary: A questionnaire of 32 items (see Appendix) was evolved dealing with quantitative aspects of everyday experience and the general interest in, and attitude toward, mensuration and numerals. This instrument was administered to a male and female group of high school students in the tenth grade. An item analysis indicated a total of 13 items which discriminated effectively between the two sexes. Females were notably more acquiescent to items involving compulsive enumeration. Males, on the other hand, were generally higher on items involving confidence and familiarity with numbers and quantification.

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APPENDIX

[redacted]

Name:_____

Grade:_____

ATTITUDE SCALE TOWARD NUMERALS & NUMBERS

Instructions: Please answer all items. So far as possible, use the "yes" and "no" categories, avoiding the "?". Encircle your answer.

YES	yes	?	no	NO	1.	Did you find learning numbers easier than learning letters when you were a child?
YES	yes	?	no	NO	2.	Do you have any feelings about lucky and unlucky numbers?
YES	yes	?	no	NO	3.	Do you usually like to keep score in games and sports?
YES	yes	?	no	NO	4.	Do you find it more fun to add numbers than to subtract them?
YES	yes	?	no	NO	5.	Do you consider that boys and men are naturally more proficient in mathematics?
YES	yes	?	no	NO	6.	Do you think you have a better sense of rhythm than most people?
YES	yes	?	no	NO	7.	Do you think some people are naturally blind to arithmetic and mathematics?
YES	yes	?	no	NO	8.	Have you ever identified colors with different numerals?
YES	yes	?	no	NO	9.	Is 9 more "important" than 1?
YES	yes	?	no	NO	10.	Do you think you enjoy gambling more than most people do?
YES	yes	?	no	NO	11.	Do you frequently count steps in a staircase just for the fun of it?
YES	yes	?	no	NO	12.	Do you think you find it easier than most people to remember street and telephone numbers?
YES	yes	?	no	NO	13.	Do you sometimes find yourself counting cracks in the sidewalk?
YES	yes	?	no	NO	14.	Are you generally better in mathematical subjects than in those requiring verbal skills?
YES	yes	?	no	NO	15.	Do you ever have certain numbers going over and over in your head?

YES yes ? no NO 16. Do you get a pleasurable sense of completion out of adding correctly a column of numbers?

YES yes ? no NO 17. In your visual imagery, can you imagine a number being written down and then erase it at will?

YES yes ? no NO 18. Would you have serious objection to living on a street designated by a number rather than a name?

YES yes ? no NO 19. Are you particularly skillful at guessing the time?

YES yes ? no NO 20. Do you feel most people are required to remember too many numbers in the course of their ordinary existences?

YES yes ? no NO 21. Do you think you have a richer body of associations to numbers than most people?

YES yes ? no NO 22. Do you generally maintain your orientation with respect to North, South, East and West better than most people?

YES yes ? no NO 23. Did you ever take any non-required courses in mathematics just for fun?

YES yes ? no NO 24. Has it ever occurred to you that our system of numerals is more complex than it need be?

YES yes ? no NO 25. In general, do you prefer even numbers over odd numbers?

YES yes ? no NO 26. Do you keep an accurate account of your finances?

YES yes ? no NO 27. Are you fond of playing cards?

YES yes ? no NO 28. Is it especially annoying to you to have telephone numbers all in digits?

YES yes ? no NO 29. Do you think you are a better judge of distance than most people?

YES yes ? no NO 30. If you are reading a book, do you keep track of the number of pages you have read or the number still to be read?

YES yes ? no NO 31. Do you feel the assignment of numbers to people is dehumanizing?

YES yes ? no NO 32. Do you much prefer word and letter games over number games?